Mathematical Model of the Ionospheric Electric Field, which Closes the Global Electric Circuit

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A model for the distribution of the ionospheric potential which drives the currents which close the global electric circuit is constructed. Only the internal electric fields and currents generated by thunderstorms are studied. The atmospheric conductivity profiles with altitude are empirically determined, and the topography of the Earth's surface is taken into account. A two-dimensional approximation of the ionospheric conductor is based on high conductivities along the geomagnetic field; the Pedersen and Hall conductivity distributions are calculated using the empirical models IRI, MSIS and IGRF. It is shown that the longitudinal and latitudinal components of the ionospheric electric field of the global electric circuit under typical conditions for July, under high solar activity, at the considered point in time, 19:00 UT, do not exceed 9 microV/m , and in the sunlit ionosphere they are less than 2 microV/m. The calculated maximum potential difference in the E- and F-layers is 42 V; the maximum of the potential occurs above African thunderstorms that are near the terminator at that time. The minimum potential occurs near midnight above the Himalayas. In our model the potential has identical values at ionospheric conjugate points. The voltage increases to 55 V at 23:00 UT and reaches 72 V at 06:00 UT, when local midnight comes, respectively, for the African and Central American thunderstorm areas. These voltages are about twice as large for solar minimum conditions. With our more realistic ionospheric model, the electric fields are found to be an order of magnitude smaller than those of the well-known model of Roble and Hays, 1979. The first results of our modelling efforts are presented in the following paper, with a published correction to the paper.

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Roble R.G., Hays P.B. (1979) A quasi-static model of global atmospheric electricity. 2. Electric coupling between the upper and lower atmosphere. J. Geophys. Res. 84(A12), 7247–7256. DOI: 10.1029/ JA084 iA12p07247